Strategy and Tactics in Thermoelectric Material Science

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The thermoelectric effects of Seebeck, Peltier, and Thomson considered as core to the building of thermoelectric module which converts thermal energy into electrical energy or cooling systems creation [1]. The efficiency of thermoelectric materials characterized by dimensionless quantity – thermoelectric figure of merit

$$ZT = \frac{S^2 \sigma T}{\chi}.$$

In this expression S is the coefficient of Seebeck, σ – specific electrical conductivity, T – temperature, and χ – coefficient of heat conductivity.

The better the efficiency of thermoelectric material determined of the higher value of ZT.

Glen Slack most clearly formulated the strategy in thermoelectric material: the best materials are agreement to the concept of "phonon glass – electronic crystal." Namely, phonons must be disordered, like glass, and electrons must have high mobility that is inherent in crystalline semiconductors.

As for tactics, they are different and should be attributed to the massive crystals, composites and quantum-dimensional structures.

Massive crystals. The substitution atoms of main matrix by impurities causes to reduction of χ and to growth of S (examples of these materials: Bismuth (Lead) Telluride, Skutterudite, Clathrates, LASTs, OCBs, JALTT).

Composites. There is a scattering of phonons (decrease χ) and increase of S by throttling carriers on the grain boundaries.

Quantum-size structures: *walls, wires, dots*. These structures are characterized by power throttling carriers in the barriers, "carrier-pocket" engineering, and transition from semimetal to semiconductors.

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